Chapter V
Conclusion
5. Conclusion

The first aim of the present work is to design and synthesise tailor made multi-metallic complexes. This has been achieved by assembling mono-metallic precursors and in a step-wise fashion, the bimetallic, trimetallic and tetrametallic complexes with suitable bi- or multi-dentate bridging ligands containing N- or O-donors, such as 1, 10-phenanthroline-5,6-dione, N,N-dimethylethlylenediamine, N,N'-dimethylethlylenediamine, triethylene-tetramine, 2,6-bis(phthalomethyl)-4-chlorophenol-dihydrochloride have been synthesized. Of which, the 1, 10-phenanthroline-5,6-dione served as a promising bridging ligand. The synthetic strategy followed in this work allows one to prepare multi-metal coordination complexes with predefined position and to an extent can synthesise with predefined geometry and electronic properties. Thirty seven complexes with the first row transition metal ions of types Cu-Cu, Cu-Co, Cu-Ni, Cu-Mn, Cu-Zn, Cu-Cu-Cu, Cu-Co-Cu, Cu-Ni-Cu, Cu-Zn-Cu, Cu-Mn-Cu, Co-Co-Cu, Ni-Cu-Ni, Mn-Cu-Mn, Zn-Cu-Zn, Cu-Cu2-Cu, Cu-Zn2-Cu, Zn-Cu2-Zn, Fe-Cu, have been synthesised and reported.

Various analytical studies are employed to reveal that the different metal ions do not lose their individual chemical identity in a multi-metallic environment. FAB mass, IR, CV studies for all the complexes have comprehensively confirm the formation of the complexes. A detailed study on EPR to probe the electronic and structural behaviour of the complexes has been done. The EPR spectra are simulated in terms of their spin Hamiltonian parameters, $g_{xx}$, $g_{yy}$, $g_{zz}$, $A_{xx}$, $A_{yy}$, $A_{zz}$, $g_{xy}$, $A_{10}$, $A_{110}$ and line width etc. The estimation of spin Hamiltonian parameters is achieved by complete simulation of EPR spectrum with second order
perturbation to completely unravel the structural and electronic details of individual metal complexes. The electronic characteristics of the various metal complexes have been identified from the A values and the appropriate geometry around the metal center has been identified from the g values. Thus the geometry around copper(II) ion is more distorted in bimetallic complexes than in the monometallic complexes with the aromatic diamine ligands. In contrast, the aliphatic diamines and tetraamines provide more flexibility around copper(II) ion and generally found to stabilize in a Jahn- Teller distorted square geometry.

The binding studies of the complexes with calf thymus DNA are carried out through fluorescence emission. The binding constants’ trends can be summarized as monometallic < bimetallic ≤ trimetallic and with respect to the nature of the diamine ligands, aliphatic diamines > aromatic diamines. The higher binding constant in multi-metallic complex as conferred to monometallic counterparts is attributed to additional covalent binding at the metal centres. This covalent type interaction may be dominating in complexes coordinated to aliphatic diamines. Also, the aliphatic diamines might bind with the minor groove of calf thymus double helix DNA by non-covalent mode, possible involving electrostatic, hydrogen binding and Van der Waals interaction. Among the metal ions used, Ni(II) and Co(II) show higher binding activity due to its preferentially coordination to N-7 nitrogen of purines. Thus these synthesized complexes provide a platform for multiple coordinating sites with DNA thus providing a way for lower dosage. It can be emphasized that the binding efficiency of the metal complexes may not increase by increasing the number of metal centers but by choosing appropriate metal ion centers.
The cleavage properties of the metal complexes with the plasmid (pBS DNA) DNA have been studied through agarose gel electrophoresis. The cleavage property of the complexes depends on conditions like the substrate concentration, concentration of the compound, temperature, time of incubation, pH etc. A thorough study in this direction may be required to understand the cleaving efficiency of the metal complexes. However all the complexes are known to cleave DNA at a concentration of 10 μM. In consistent with the DNA binding studies of the complexes through fluorescence, the cleavage activity of the bimetallic Cu-Ni, Cu-Co show 50% cleavage activity at 2 μM. Fe(L1)3 shows complete cleavage of DNA at 2 μM, thus a promising candidate for anti-tumour drugs.

Thus this synthetic strategy can be used to build up multi-metallic complexes of ones choice and alter the structural and the electronic property of the metal complexes. Thus we conclude that the lighter first row transition metal ions are no where inferior to the heavier metal ion complexes of Pt, Ru, Pd and Ir to show binding efficiency with DNA paving way for these biologically soft metal ions to find its way to clinics.